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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of
Paul van de LOO
Application No.: 10/677,256
Filing Date: October 3, 2003
Title: CONTROL SYSTEM FOR A COGENERATION UNIT

Group Art Unit: 3661
Examiner: Unassigned
Confirmation No.: 9099

SUBMISSION OF CERTIFIED COPY OF PRIORITY DOCUMENT

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Sir:

The benefit of the filing date of the following priority foreign application(s) in the following foreign country is hereby requested, and the right of priority provided in 35 U.S.C. § 119 is hereby claimed.

Country: Australia

Patent Application No(s).: PR 4189

Filed: April 4, 2001

In support of this claim, enclosed is a certified copy(ies) of said foreign application(s). Said prior foreign application(s) is referred to in the oath or declaration. Acknowledgment of receipt of the certified copy(ies) is requested.

Respectfully submitted,

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Date: 2-6-04

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I, JANENE PEISKER, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PR 4189 for a patent by APPLIDYNE PTY LTD as filed on 04 April 2001.

WITNESS my hand this
Twenty-fifth day of November 2003

JANENE PEISKER
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ORIGINAL

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PATENTS ACT 1990

PROVISIONAL SPECIFICATION FOR THE INVENTION ENTITLED:

"CONTROL SYSTEM FOR COGENERATION UNIT"

This invention is described in the following statement:-

FIELD OF THE INVENTION

This invention relates to cogeneration systems and particularly, to controlling a cogeneration unit which may be connected to the mains power grid.

BACKGROUND TO THE INVENTION

Currently, most electricity is generated by large power stations using fuel such as natural gas or coal. In this traditional method of electricity generation, approximately only one third of the energy from the fuel is converted to electricity, while approximately two thirds is converted into heat. This heat energy, while potentially useful, is difficult to sell to consumers, as this heat is difficult to transport and potential users are generally some distance away. The heat generated is thus often not used and is surrendered to the atmosphere through cooling towers or through cooling water from the sea. At the same time, potential users of such heat including factories, hospitals and heated swimming pools generally then generate their own heat by burning more fuel to produce heat, or by the use of electricity for heating. This is clearly a highly inefficient method of generating heat and electricity and it has been found that it is far more cost effective and efficient for such users to install their own small power stations, such that they can use the waste heat generated from the electricity generating process directly, to meet their own heating requirements.

The simultaneous production of usable heat and electricity in the same plant is known as cogeneration. Cogeneration units are used in many industrial applications as described above, however the concept is equally applicable to domestic environments such as households which require heating for hot water and general heating of the environment, particularly in colder climates.

The benefits of cogeneration for domestic or household use can be enhanced if surplus electricity generated from such units can be sold to the electricity grid for use by other households or commercial users. Furthermore, mains connection allows power for peak household loads to be drawn from the grid. The cogeneration unit then does not need to be sized to meet these peak loads. A number of methods have previously been proposed to achieve this, however current methods are generally very expensive and rather complex to design and install.

Accordingly, it is an object of the present invention to provide a control system for use with a cogeneration system which can be connected to the mains power grid in a more simple and cost effective manner.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided a control system for a cogeneration unit, the cogeneration unit including a heat engine and an alternator which may be powered by the heat engine, to generate AC electricity, the control system including;

parameter sensing means for sensing one or more desired parameters of the generated AC electricity; and

one or more control means for directly controlling the one or more desired parameters in accordance with the result of a comparison between the one or more sensed desired parameters and a respective one or more preset parameter value.

Preferably, the desired parameters include voltage, frequency, current and power factor.

The cogeneration unit is able to be selectively connected to and disconnected from, the mains power grid, without the need for an inverter.

In the mains-connected mode, the parameters of voltage and frequency of the alternator are controlled in accordance with the corresponding parameters of the mains power supply. Power fluctuations are addressed by the use of a variable dummy load which is used to dissipate excess power and compensate for variations in household load requirements.

BRIEF DESCRIPTION OF THE DRAWINGS.

The preferred embodiment of the present invention will now be described in detail with reference to the following figures in which:

Fig 1 is a schematic diagram of the control system of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention may be used in two modes. The first mode is the stand-alone mode, in which the cogeneration unit operates in isolation of the mains power grid. The second mode is the connected mode, in which the unit is connected to the mains power grid and operates in conjunction therewith.

At the heart of the system, is alternator 100 which is powered by heat engine 10. The source of power for heat engine 10 is, in this particular embodiment, a gas supply, the supply of which is controlled via gas flow regulating valve 20. The gas supply to heat engine 10 is burnt by gas burner 11, which causes the heat engine to operate.

At initial start up, the burner 11 is turned on to begin operation of the heat engine. Power is also provided to DC motor 30, for a short period of time to initiate the rotation of alternator 100, until heat engine 10 can properly take over this task. The operation of the DC motor is controlled by start up controller 40 which is connected to battery 45 which in turn is connected to battery charger 46. Battery charger 46 is connected directly to the power supply 60.

Alternatively, an additional winding can be added to the alternator with suitable control arrangements to start up the alternator.

As the frequency of the alternator approaches the desired frequency, a variable dummy load is applied. The magnitude of the variable dummy load is ramped up slowly, by use of a triac, as explained in more detail below.

In the stand-alone mode, switch 61 is actuated to disconnect the mains power supply from the system. Isolation contactor switch 62 is actuated to connect the output from the alternator 100 to the household load 70. Accordingly, household load 70 can be connected directly to the mains, via switch 61, in isolation of the unit of the present invention, via switch 62, or directly to the cogeneration unit, in isolation of the mains. It is of course also possible to have the household load 70 connected to both the mains and the cogeneration unit in times where the power requirements of the household load 70 exceed that able to be generated by the cogeneration unit. Additionally, when output does exceed the household load requirements, the excess power can be provided to the mains supply, in effect selling power to the power company.

In the stand-alone mode, AC electricity is generated by alternator 100 at the desired frequency and voltage directly, without the use of an inverter. The AC electricity generated by alternator 100 is sensed by parameter sensor 80, which can measure the frequency, voltage, current and power factor of the AC electricity generated. Parameter sensor 80 can also sense the frequency and voltage of the mains power for connecting the unit to the mains (see below). A feedback loop is provided to control the operation of the alternator 100, such that the frequency and voltage of the electricity generated by alternator 100 can be controlled to match desired parameter values. The desired frequency value f_{des} is input at junction 81, while the desired voltage, V_{des} is input at junction 82. Any difference between the actual value sensed and the desired value, results in a control signal applied either directly or indirectly to alternator 100 to regulate its operation, such that the respective parameters of the output AC electricity generated by alternator 100 matches those of the corresponding desired values.

To control the frequency of alternator 100, switch 82 is set to the stand-alone mode thereby connecting resistive load controller 90 to Triac 110. Resistive load controller 90 controls the switching operation of Triac 110 to effectively vary the resistive load (or variable dummy load) on the output of alternator 100. The variable dummy load in this particular embodiment is in the form of a heating element (122) located in hot water tank 120. The amount of resistive loading can be varied by the effective amount of time the Triac is on. For example, if the effective resistive loading required on alternator 100 is three eighths of the maximum resistive loading, then the triac will switch so as to connect variable dummy load 120 to alternator 100 every three out of eight cycles. In practice, the Triac will be switched on for an entire half cycle, for each cycle that is desired to be on. In this way, all switching can be done at zero volts. It is important however that the switching occurs on alternate positive and negative cycles to avoid a DC output.

This triac control methodology may lead to mechanical vibration and stress problems as the frequency of torque fluctuations associated with the triac load switching is relatively low. An alternative is to use phase angle control of the triac switching, in which the load is switched every half cycle.

This results in larger currents being switched, but results in smoother control, as the torque fluctuating frequency will be higher. Filtering may be used to prevent electrical noise associated with the switching from entering the household electrical system.

Since the frequency of the output of the alternator is determined by the heat engine speed, increasing and decreasing the resistive load effectively increases and decreases the heat engine speed. However, it is not possible to vary the speed of the heat engine rapidly, and accordingly, significant load transients result.

Load transients are dealt with by varying the effective resistive load (or variable dummy load) 122 which converts excess electricity to heat. The fuel flow to the heat engine is such that the electric power generated is in excess of normal requirements. This excess is consumed in the variable dummy load and provides "head room" for electrical load increases. This again is controlled by resistive load controller 90. As the household requirements increase, the excess is slowly reduced from its nominal value until it is zero, when household demand matches the alternator output. If the heat generated is not being utilised, the alternator output will reduce as the thermostat control attempts to control the hot water temperature. Thus, to obtain maximum electricity output to the household, it is necessary to ensure that there is sufficient heat load on the hot water system.

The control of the voltage of the output AC electricity is achieved by controlling the field winding current on the alternator (or the equivalent on permanent magnet hybrid alternators). In the stand-alone mode, switch 63 is actuated so as to connect the voltage feedback loop (via junction 82) to the field current controller 130. This then applies appropriate control signals directly to the alternator to control the field winding current.

The supply of gas to heat engine 10 is controlled by gas flow regulating valve 20 which in turn is controlled by the output of junction 84, the output of which is a difference between a desired temperature T_{des} and the sensed temperature of the hot water tank 120, which is sensed by temperature sensor 121.

When operating in the mains connected mode, the cogeneration unit is connected directly to the mains grid via switches 62 and 61. Power can flow to or from the grid depending upon the cogeneration output and the household usage. The household heating requirement determines the amount of power generated by the cogeneration unit by varying the amount of gas supplied to heat engine 10.

An additional feature which may optionally be added to the present invention, for the stand-alone mode is the concept of an "electrical priority" mode. In this mode, the heat dissipated in the variable dummy load 122 is increased, resulting in an overheating of the house. This control accordingly overrides the thermostat control 121/84, for a limited period only, to meet peak household loads.

Such a mode may be invoked if the householder wishes to operate an appliance with high electrical load. The home heating system then needs to be designed to dissipate heat at greater than usual thermostat set temperatures.

In the mains connected mode, the burner is started to initiate operation of heat engine 10. Similarly, power is supplied to DC motor 30 for a short period of time to initiate the operation of alternator 100. As before, for the stand-alone mode as the frequency of the alternator approaches the desired frequency, the variable dummy load 122 is slowly ramped in, and the isolation contactor 62 is activated to connect the unit to the household load 70. The mains frequency is monitored (by parameter sensor 80) and is used to control the speed of the heat engine such that alternator 100 has a slightly higher (or lower) frequency than that of the mains frequency. For example, if mains frequency is at 1500 rpm, the alternator will be running at 1502 rpm. In this way, the mains frequency and the alternator frequency will synchronise periodically due to the speed difference. At a point of synchronisation, switches 61 and 62 can be switched to the mains position to thereby connect the unit to the mains power grid. Alternatively, a Phase Locked Loop controller could be used for this.

With the alternator effectively directly coupled to the grid, the grid will determine voltage and frequency. The field control on the alternator is controlled to achieve the desired power factor. In this mode, switch 82 is switched from the stand-alone position to the mains position, thereby disconnecting resistive load controller 90 from Triac 110. This results in a zero value for the variable dummy load 122. Switch 63 is also switched from a stand-alone position to mains position, thereby disconnecting the voltage control feedback loop from field current controller 130 and connecting field current controller 130 directly to the power factor feedback loop of which junction 83 is a part. In this case, the desired power factor PF_{des} is compared with the actual sensed power factor from sensing unit 80 and any difference resulting from this comparison is converted to a control signal via field current controller 130 to regulate the field winding current on the alternator.

The above has been described with reference to a particular embodiment and it will be understood by the person skilled in the art that many variations and modifications are possible within the scope of the present invention.

Dated this 4th day of April, 2001.

APPLIDYNE PTY LTD
By its Patent Attorneys
MADDERNS

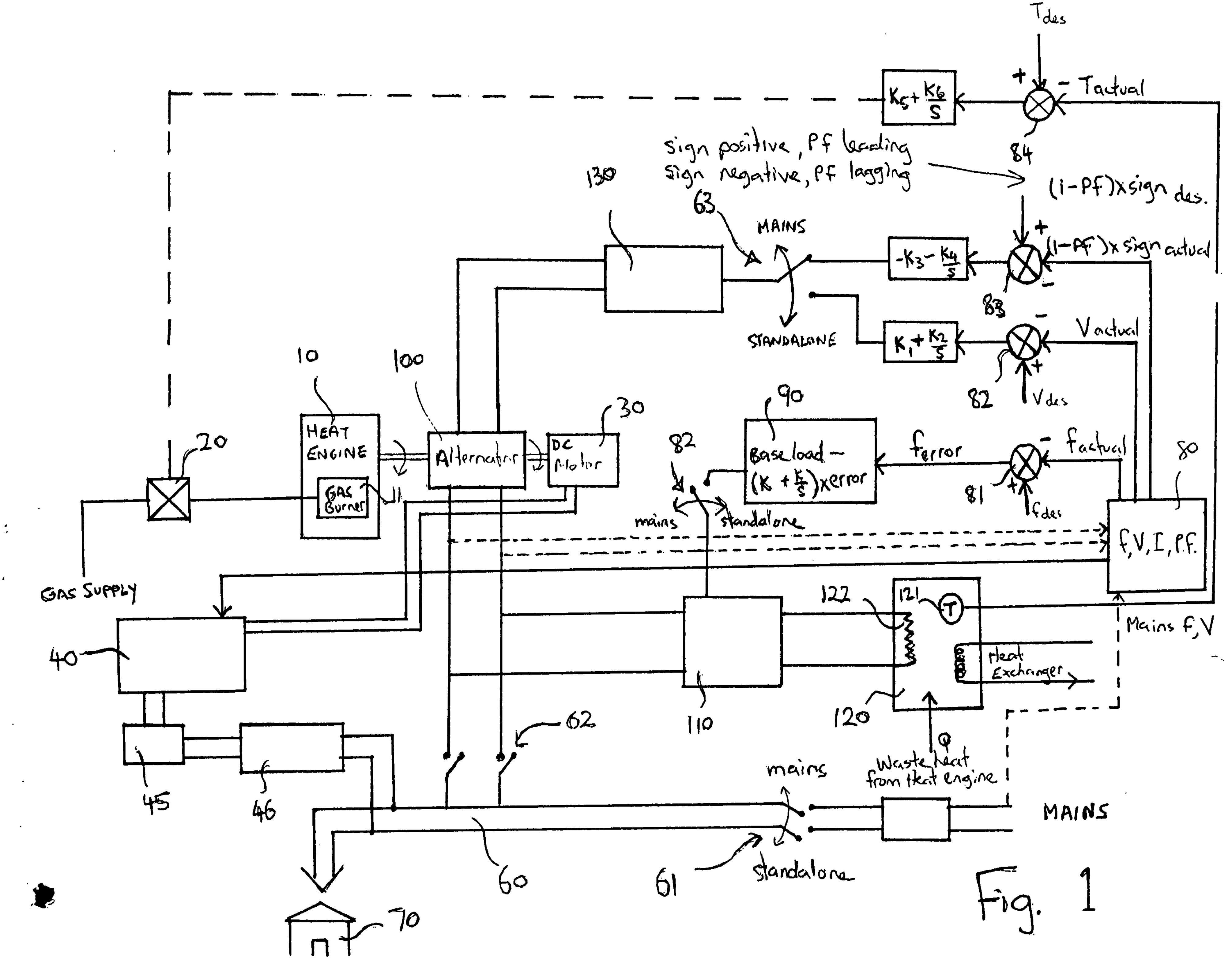
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Fig. 1

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14 November, 2003

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The Commissioner of Patents
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Dear Sir

Re: APPLIDYNE PTY LTD
Our Reference: FF35978/03
Australian Provisional Patent Application No. PR4189
Filed 4 April 2001

Please supply a certified copy of the above Australian Provisional Patent Application required in support of a corresponding application in the United States of America.

Respectfully

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David B Fitzpatrick

GJB:JE

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